Soils and soil conditions of the Amatikulu project

by

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Abstract

This report describes a soil study which was carried out in the framework of SASRI project 06TT01, “Best management practices for small-scale sugarcane growers in the Amatikulu catchment (Zululand) including alternative crops”. The soil study was carried out on the site selected between the three proposed by the community consulted for the project.
This document reports the results of the field study taken into account the results of the soil analysis carried out (by SASRI) on the samples collected at three depths for nine soil pits in the selected area for the project. The geographic centre of the site is near 28°56'19" South and 31°13'56" East. The site is located 537 ±10 m above sea level near the village of Bongolwane. It covers ca 5 ha.

The slope of the selected area is gentle when compared to other areas in the project region (but common in the sugarcane industry), and, as consequence, the soil depth is often greater then elsewhere in the region. The bedrock of the soils of the selected site, as well as for the main part of the project area, is of amphibolite type which is uncommon in the sugarcane industry and elsewhere in South African. But the soils developed on this rock type have a high agricultural potential, like for an important part of the soils of the sugarcane industry.

In the upper part of the selected area the soils are humic, clayey, rich, and between 50 - 80cm depth underlain by a strongly weathered metamorphic rock, rich in amphibolite. Mid-slope the clayey humic surface horizon of about 50 cm depth is underlain by a deep reddish brown clayey layer and at the foot slope (i.e. near the geo-structural born wetland which borders the North of the site), by a red-brownish subsoil that shows at more than 1m depth the influence of a seasonal fluctuating water table.

The topsoil - which has a depth of about 50cm - is throughout the area studied of a melanic type. The B horizon which underlies the melanic A horizon is thin in the top part of the site. This makes that the soils in this part of the site are of Mayo type according to the South African soil taxonomy and are Glossic Leptic Phaozems in the WRB (World Reference Base, edition 2007)
Downslope, the depth of the B horizon increases quickly. According to the SA soil classification system the B horizon is of Yellow-Brown Apedal B or unspecified type. At the footslope of the site the influence of the seasonal fluctuating watertable makes that the B horizon is underlain by a gleyic horizon with distinct signs of oxidation. Soils of the mid- and down slope part of the site could not be classified according to SASRI's soil handbook "Identification and management of the soils of the South Africa sugar industry at soil form level. In the WRB systems they belong to the Cambic Gleyic Phaozem

Soil chemical and physical characteristics are favourable for growing of sugarcane and other crops in all parts of the site: pH slightly to moderately acid, high CEC, low N requirement, parts of the area show deficiency in potassium and phosphorus is low throughout. The soils are easy to till, are very deep (except at the top) and have probably a high waterholding capacity. The possible influence on crop growth and husbandry operations of the fluctuating depth of the water table in the bottom part of the site has to be checked.

1 - Background

In the framework of SASRI's project "Best management practices for small-scale sugarcane growers in the Amatikulu catchment (Zululand) including alternative crops" a soil study was carried out on the three sites proposed by the local community**.**
This document reports the results of the soil survey and the soil analysis carried out on the site selected for the execution of the project.

2 - Physiography and location of the area

The area of the site is located in the sector 28°56'19" S - 31°13'56" E at about 545m above sea level. According to the 1:250 000 geological map, the bedrock of the area belongs to the Natal structural & metamorphic province (= Namibian) which is of ante-Ordovician age. It consists of amphibolite (symbol Nsa on the geological map), gneiss rich in quartz, feldspars and biotite (Ntg) and of amphibolitic gneiss (Nzg). According to our observations, Ntg is the main formation of the region which consists of sub horizontal stratified highly metamorphosed, crystallised old pelletic sediments with numerous quartz veins.
The overall landscape form (see image 1 in appendix 1) is rolling with slopes up to 30 % and valley-bottoms locally developed in wetlands. These wetlands are of geo-structural origin, i.e. due to the presence of barriers of hard rock in the substratum. Near some wetlands of the area remnants of a colluvio-alluvial terrace level can be observed, indicating that uplifting of the area occurred in recent times.

The site selected for the project (see image 2 in appendix 1) has a weak slope of about 5 % at its top part which conduct with a fair moderate convexo-concave slope (8 -> 4 %) to the wetland, located at its northern and north-eastern limit. The axe of the site is oriented SSW -> NNE.

The site is since several years used for extensive grazing but its main part was used until some years ago for (probably) cane production. This is shown by the existence of a contour oriented parallel ridged micro topography in most parts of the site and by the presence of an Ap horizon (i.d. a plough layer) which often has a less distinct fine subangular blocky (or even a massive) structure than in the parts where the soil was not tilled and trafficked (see the soil pit descriptions in appendix 2).

3 - Soil survey methods

The soil survey was carried out in June 2008. Nine pits, dug to about 1.1 m depth, were sampled, after their visual and tactile characterisation, at 3 levels per pit for analysis. Each sample send to the laboratory was made out of several subsamples taken at three walls of the opened pit. Pit 1 & 2 were dug at the upper part of the site and pits 7 to 9 at the lower part. The geographic co-ordinates of the pits are given in Table 1.

Table 1: Location and elevation of the nine sampled soil pits

Pit number	South			East			Elevation (m) asl
	Degrees	Minutes	Seconds	Degrees	Minutes	Seconds	
1	28	56	22.322	31	13	54.905	544.0
2	28	56	21.825	31	13	53.420	546.4
3	28	56	19.019	31	13	53.131	538.8
4	28	56	19.937	31	13	55.105	538.7
5	28	56	21.053	31	13	56.588	536.6
6	28	56	22.106	31	13	57.526	539.6
7	28	56	20.214	31	13	58.058	532.8
8	28	56	15.768	31	13	54.474	527.0
9	28	56	15.730	31	13	52.773	529.3

A description of each of the soil profiles is given in appendix 2; photographs of them are presented in appendix 3 and the results of the analysis carried out by SASRI's Fertilizer Advisory Service (FAS) laboratory are presented in appendices 4 and 5. The analytical methods used by FAS are summarized in appendix 6 and the threshold values for soil chemical characteristics used for advice to the cane farmers in soil fertility management by FAS are reported in appendix 7.

4 - Characteristics of the soils

4.1. Soil depth, watertable and soil taxonomy

At the upper part of the site the soils belong according the SA soil classification system to the Mayo soil form (i.e. with a diagnostic horizon succession of Melanic A/ Lithocutanic B & Saprolite C) and, according to the laboratory results, to the Msinsini series[1]. The soil depth above the saprolite (weathered rock) is about 50cm.
Midslope, the thin B horizon becomes better developed, acquiring a Yellowish brown appearance, while the soil depth above the saprolite increases. No appropriate name was found for such soils in the handbook of the soils of the SA sugar industry.
At the foot slope of the site a deep cambic B horizon[2] - called in SA system Yellowish-brown apedal B or unspecified – occurs, which is underlain by an oxidized G horizon at a depth greater than 1 m.
All soils inspected present a discrete stone line at the transition of the thick melanic A horizon and the subsoil, essentially composed of quarts gravel and stones, often somewhat rounded. This may indicate that the melanic horizon was or is subject to creep.

[1] It should be noted that, in fact, this series name is incorrect because the Mayo soil form was recognized on granite, an acidic rock, while in the Amatikulu area the Mayo soils are developed on basic rock. Due to this fundamental difference, soil chemical and tactile characteristics differ from the typical Msinsini series.
[2] In the WRB and USDA soil taxonomy systems

On the mid slope and foot slope, the B horizon and the C horizon contain black or dark-red hard pisolites, which are sometimes abundant. They were (in the up-and mid land soils) and are formed (in the low land soils) by the conjunction of fluctuating watertable and lateral waterflow.

In summary: Soil depth is limited at the upper part of the site, increases midslope, and is deep in the lower part where plant growth may also benefit (or be hampered!!) by a seasonal fluctuating water table, encountered during the field study at a depth of 1.7m at pit 9 but probably raising up to only 50 cm depth at the end of summer rains.

4.2. –Topsoil characteristics (see appendix 4, 5 and 7)

4.2.1. Organic matter, nitrogen and clay content

All the soils have a very dark blackish topsoil with a thickness of 50 to 60cm, classified in the SA soil taxonomy system as Melanic. *Organic carbon content* ranges from 2.0 to 2.9 % (i.e. 3.4 to 5.0 % of Soil Organic Matter) in the first 15-20cm and 1.9 to 2.3 % (i.e. 3.3 to 4.0% SOM) in the second part of the melanic A horizon.

In 6 of the 9 soil pits, the uppermost 15 to 20 cm of the A horizon is of Ap kind - a (once) ploughed layer - which has lost totally or partially the distinct fine subangular blocky structure presented by the soils that were not affected by tillage and subsequent trafficking during harvest (see appendix 2). Despite these men induced actions, the SOM content of the Ap horizon is not systematically lower than the other one.

The SOM % as estimated by a NIR (Near Infrared Red) method is about twice[3] the value as determined by the Walkey-Black method, the one usually used at SASRI until recently.

According to the results of the particle fraction analysis done by SASRI's soil physics laboratory, the melanic A contains 36 to 42 % *clay*, without a significant difference in % clay between the two sampled levels of the melanic horizon in each of the 9 soil pits.

The silt fraction in the A horizon (as well as deeper in the soils) is low: only 4 to 11 %.; much less than estimated in the field.

Surprisingly, the clay/silt ratio varies from 3 to 20 which is uncommon. Probably this large range is due to way at which at SASRI the hydrometer method is used for determination of the clay and silt fractions (see appendix 6).

The ratio "C%/clay%[4]" ranges from 4.2 to 7.4 in the A horizon and show only in the lower part of the area (pits 7 to 9) a distinct tendency to be lower in the second part of A level than in its top part. The ratio being in the top part of the area relatively very high (6.8 to 7.4), as well as its %C (2.6 to 2.9), this may indicate that the mineralisation rate of the fresh organic matter which enrich yearly the soil is higher in the topsoil of the lower part of the area. We attribute this to the fact that, as already stated, the soils of the lower part of the area are influenced by a seasonal fluctuating water table and present for this reason more favourable conditions for mineralisation of organic matter[5].

The amount of *total nitrogen* in the melanic A horizon ranges between 0.6 and 1.5 ‰ in the toplayer and between 0.5 and 0.9 ‰ in the second level of the A horizon.

Compared to their amount of total C, these N levels are low as reveal the C/N ratio: between 19 and 35 for the top level and ranging between 24and 39 for the second one. The surprisingly high C/N ratio may be due to an incorrect execution of the method used for the determination of total N.

The value reported for *NH_3%* in appendix 5 in the top level of the A horizon is 0.1 for the nine sampled soil pits. The NH_3% is an index for the amount of N fertiliser that would be lost in

[3] 1.6 to 2.5 times for the different samples
[4] Calculated for "100* C%/ Clay %"
[5] During the winter season, the humidity conditions are in the A horizon of the lower part of the area more favourable for microbiological breakdown of the organic matter than in the top and mid part of the area.

the form of ammonia following the topdressing of urea. As could be expected by the pH-water of the nine topsoils, their high SOM and nice structure, the risk of N volatilization is very low.

> Note that the reported values for NH_3% of the deeper soil layers in appendix 4 lack any practical significance. They show only that when pH-water is ≥ 6.7 the risk of ammonium losses increases when urea is applied and become noticeable at a pH above 7.0.

All the sampled pits have a melanic horizon of *N category*[6] 4, i.e. with high potential of N supply by mineralisation of the soil organic matter. This reduces the amount of N fertiliser needed on these soils.

4.2.2. pH, CEC and exchangeable cations

pH-water of the upper part of the melanic A horizon ranges between 5.5 and 5.9 and is thus moderately acidic. In the lower part, the pH increases with half a point to 6.0-6.5. These conditions are good for cane and most food and fodder crops.

The melanic horizon of all the soil pits is rich in *exchangeable* Ca^{2+} *and* Mg^{2+}. Their ratio[7] varies between 0.9 and 2.1 in the top level and between 1.2 and 3.0 in the second part. Often it increases in the second part of A in the soil pits. These ratios are correct for most crops, including sugarcane.

The level of *available potassium* is very variable in the top part of the A horizon where it is between 0.14 and 0.79 $cmol^+.kg^{-1}$ (resp. 53 and 307 ppm), i.e. varies from very poor to very rich. On the other hand, exchangeable potassium is uniformly very low in the second part (0.09 to 0.14 $cmol^+.kg^{-1}$, resp. 34 and 53 ppm).
The huge differences in amount of available potassium in the top layer existing at short distances are men induced. Not to differences in mineral fertilisation in the past but rather to the fact that in the past parts of the site were cropped without mineral fertilisation because it are the Ap horizons that show the lowest value in exchangeable K.

The *cation exchange capacity* of the melanic horizon, as measured conventionally by the acetate method at pH 7.0, is estimated to be between 20 and 25 $cmol^+.kg^{-1}$, in other words, moderate to high. This range for CEC was deduced from the sum of measured exchangeable Ca, Mg and Na (between 12 and 23 $cmol^+.kg^{-1}$, see appendix 5), and by taken into account that (i) exchangeable Na was not determined, and (ii), the pH-water of the melanic horizon being < 7 (and sometimes down to 5.5) also H^+ and even Al^{3+} should be present on the CEC. Expressed per kg clay, the CEC value range is estimated to be between 50 and 60, i.e. 30 to 40 $cmol^+.kg^{-1}$ after deduction of the contribution of the organic matter to the CEC. These CEC values suggest that the clay fraction is mainly of chloritic-ilitic type and contains probably also clays of the smectite[8] family.

4.2.3. Phosphorus, silicon and zinc

Available phosphorus, as determined by the Truog method, ranges in the top part of the A horizon between 5 and 15 ppm and is only between 2 and 5 ppm in its second part. The status of available P is thus very low for plant cane and low for ratoon crops (see appendix 7). As for available K, the highest values for available P recorded for the top level concern A horizons without signs of tillage in the past.

[6] The category gives an indication of the amount of N potentially mineralized by the top soil during the growing season of sugarcane, ranged in 4 categories: 1= low, 4 = high.
[7] For Ca and Mg values expressed in $cmol^+.kg^{-1}$
[8] 2/1 lattice swelling clays

The *phosphorus desorption index (PDI)*[9] is in the top part of the A horizon 0.3 to 0.4 (i.e. moderately to weakly soluble P fixing). In its second level the index is only 0.1 to 0.2 indicating a higher fixation capacity of applied soluble phosphorus.

Available silicon ranges in the top part of the A horizon between 58 and 86 ppm, except in pit 9 where its amount reaches 112 ppm. In the second level of the A horizon, available Si is in the same order (minimum 61, maximum 117 ppm). Considering the threshold values reported by Kanamugire *et al*. (2008)[10], and the clay content of the soils, Si deficiency can be expected.
The ratio available Si/Clay and available Si/C, reported in appendix 5, tend to show that at the studied site the available Si amount depends, surprisingly, more of the organic C % of the soil than its clay content, because the ratio is much higher with C than with clay.

Available zinc is between 0.7 and > 4 ppm in the upper part of the A horizon, but only between 0.2 and 0.4 ppm in the lower part. Globally the available Zn level is thus fair in the topsoil, the threshold value being 1.0, but is insufficient in the second sampled soil level.
It should be noted that the topsoil of pits 5 and 6 have a high Zn level (resp. > 4 and 3.6 ppm) as compared to the top level of the other soil pits (between 0.7 and 2.0 ppm) despite that the Zn level of the 3 other sampled layers of these two pits are similar to the one observed in the other six pits. We do not have an explanation for this surprising difference in Zn level in the top layer between the 9 pits.

4.3. Characteristics of the subsoil (see appendix 4, 5 and 7)

This section gives information on the characteristics of the soil below the melanic A horizon (considered in § 4.2) of the 9 profiles studied.

4.3.1. Rooting depth

In the upper part of the site, the rooting depth is limited by the existence of weathered rock material at 50-60cm depth in which roots penetrate only in the existing tongues of A like material. The rooting depth increases quickly downslope, and at the bottom of the study area such physical barrier for root development in depth does not exist anymore.

4.3.2. Organic matter, nitrogen and clay content

In the upper part of the area, the *clay content* of the material directly underlying the melanic A horizon, i.e. saprolite presenting thin tongues of A like material, is of course very low (2-4 %) as well as is its content in organic matter (0.30-0.34 %) and nitrogen (0.1 ‰[11]).
Downslope, the B horizon underlying the melanic A, presents a clay content which varies from 44 to 63 % between the 9 sampled pits, and which is always higher than in overlying A horizon. The relative increase[12] in % clay varies between 29 and 44 %, except for pit 9 where it is only 16 %.
The SOM content is between 1.3 and 2.0 %, i.e. 1 to 1.5 point less than in the A horizon, and consequently (i) the ratio "100*Organic carbon %/ Clay %" (1.4 and 2.4), and (ii), the nitrogen level (0.4 and 0.5 ‰) are much lower than in the A horizon.

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[9] Phosphorus desorption index: strongly P-fixing (PDI<0.2), moderately (0.2 to 0.4), weakly P-fixing (PDI>0.4).
[10] Kanamugire A., Meyer J., Brouwers M. 2008 Evaluation de méthodes d'extraction chimique du sol pour prévenir les besoins en silicium de la canne à sucre. In : 4ème Rencontre internationale francophone, 11 au 14 mars 2008, Le Gosier, Guadeloupe / AFCAS.
[11] i.e. 100 ppm
[12] Expressed with reference to the clay content of the overlying A horizon of the same soil pit.

As for the melanic horizon the values of the *C/N ratio* are unusually high (17 to 27).

4.3.3. pH, CEC and exchangeable cations

pH-water is slightly alkaline (7.3-7.4) in the saprolite, but slightly acidic (6.7 – 6.9) elsewhere in the subsoil of the profiles, except in pit 9 where the pH reaches 7.8 in the B horizon.

Like the A horizon, the deeper soil layers are rich in e*xchangeable (available) Ca and Mg.* Their ratio varies between 0.8 and 1.4. They are poor in available K (0.07- 0.10 $cmol^{+}.kg^{-1}$). The *CEC of the clay fraction* is similar to that of the A horizon.

The three subsoils showing a pH-water above 7.0 are also marked by the presence of *sodium* at the CEC at the level of 0.45 to 0.93 $cmol^{+}.kg^{-1}$ (or 102 to 215 ppm Na), i.e. 7 to 15 times the amount of potassium at the cation exchange complex. This Na may compensate a deficiency in K for crop growth. Despite the noticeable amount of Na^{+}, the ESPK value[13] is low (2.0 to 5.8).The combination of a relatively high pH and the presence of a noticeable amount of exchangeable Na may indicate the presence of some sodium bicarbonate ($NaHCO_3$) in the soil solution.

It has to be noted that the amount of exchangeable Na is determined by FAS only when pH-water is above 7.0. This explains why no data are reported for this element in the appendix of this document for the samples with a pH-water ≤ 7[14].

4.3.4. Phosphorus, silicon and zinc

Despite that at medium term the amount of these three nutrients in the subsoil lack any significant practical importance, we comment them, because at long term they may have.

Available *phosphorus* is very abundant in the saprolite (104 ppm or more) of pit 1 and 2, and, as consequence, this soil material show almost any retrodegration of applied soluble P (PSI = 0.8). At the contrary, available phosphorus is low to very low (12 to 0 ppm) in the subsoil of the other sampled pits which has also a high fixation capacity for soluble P (PSI = 0.1). Available *zinc* (Zn) is very low (0.1-0.2 ppm) in depth of all soils, but available *silicon* is very high (110 to 440 ppm)

[13] ESPK = Exchangeable sodium + potassium percentage: like ESP (Exchangeable Sodium Percentage) an index of the propensity of the soil to structure loss, a notion developed at CIRAD because exchangeable K is, like Na, an dispersant cation. Note that Mg is sometimes also considered to present a dispersant action.

[14] Note that exchangeable Na may be abundant in soils with pH ≤ 7, like in salt affected soils, some solods and when soils are developed on Na rich bedrock.

APPENDIX 1: Areal views of the project area

1 - View of the region of the project & location of the three proposed sites

2: View on the selected site
(Amatikulu 2 on image 1)

APPENDIX 2: Description of the sampled soil pits

Present land use of the area and activity of soil fauna: Extensive grazing land with kikuyu, other spontaneous grasses and herbs which cover almost completely the surface of the soil; scattered bushes, some small trees; scattered termite hills of dome type and of black colour in the highest part of the area but brown in the middle en lower part.

Soil colour: Given according to the Munsell Soil Colour Chart and reported for uncrushed humid soil
Soil structure: Reported by codes: Me =. Massif overall structure, breaking down in subangular .blocky peds; Ps = subangular blocky; If there are two symbols for the structure separated by "/" the first symbol refers to the overall structure and the second to the substructure.
Root abundance: Reported by codes: R4 = very abundant..... R0 = nil
Porosity: Reported by codes: P4 = very porous ......P0 = almost any visible pore
Texture: as appreciated in the field.
Soil classification: According to
- SA system: cf. "Identification & Management of the soils of the South African sugar industry, SASEX 1999".
- WRB system: cf. IUSS Working Group WRB. 2007. *World Reference Base for Soil Resources 2006*, first update 2007. World Resources Reports No. 103. FAO, Rome

PIT 1

Site description: Slope: 5-6 %; Surface topography: ridged (h = 10-15cm, of old cane growing?), scattered black termite mouths
Soil profile description:

0 - 22 cm	Ap, dry, very dark greyish brown (10YR3/2); clay loam with 30-35 % clay; structure: Me/Ps, medium; porous; R4-3; clear smooth boundary with
22 – 43 cm	A2, dry, black (10YR2/1); 40-45 % clay; 2-5 % quartzic gravel; structure Ps; R3-2; clear wavy boundary, underlined by a discontinuous stone line of quarts, with
43 – 64 cm	AC, dry, black (10YR2/1), A like silty clay material + strong brown (7.5YR5/8), weathered R material; R2; clear wavy boundary with
64 – 120 cm	(R), dry, saprolite, tongues of dark greyish silty loam A like material; R0-1

Soil classification
- SA system: Melanic A/ Lithocutanic B & Saprolite; Mayo soil form, Msinsini series.
- WRB system: Glossic Leptic Phaozem
Effective rooting depth: 65cm
Sampling depths: 0-20, 25-40 and 70-100cm

PIT 2

Site description and soil profile: very similar to pit 1; slope 5 %.
Soil levels:

0 -22 cm	Ap
22 – 40 cm	A2; boundary with AC underlined by a discontinuous stone line, locally up to 5cm thick, containing quarts gravel and stones but also some small black and reddish concretions.
40 – 60 cm	AC
60 – 100 cm	(R)

Soil classification: same as pit 1
Effective rooting depth: 60cm
Sampling depths: 0-20, 25-35 and 80-100cm

PIT 3

Site description: Similar to pit 2 but more grasses; slope 6-7 %; height of ridges 10cm
Soil profile description:

0 – 20 cm	A1; dry, black (10YR2/1); loamy clay; structure Ps, medium fine;
20 – 45 cm	A2 similar to A1 but more clayey; discrete line with quarts stones and some fine gravel at the bottom of the A2 level;
45 – 95 cm	AC (or B?); dark brown (7.5YR3/2) A material with 30 % yellowish-red (5YR5/8) saprolite; P4-3
95 – 110 cm	CA, saprolite with tongues of A like materiel, P2

Soil classification:
- *SA system*: Melanic A/Neocutanic B/Lithocutanic B & Saprolite. Variant of Mayo soil form (not reported in the handbook of the soils of the South African sugar industry)
- *WRB system:* Glossic Leptic Phaozem

Effective rooting depth: > 110cm
Sampling depths: 0-15, 25-40 and 60-90cm

PIT 4

Soil surface state: similar to pit 2; slope 8%
Soil profile description:

0 – 17 cm	Ap (in attenuated form); black (10YR2/1); structure Me/PS weakly developed; P3; R3; very distinct and smooth boundary with
17 – 40 cm	A2; black (10YR2/1); loamy clay; Ps structure, well developed; P4, R3
40 – 45 cm	A3, stone line; P2-3; R1;
45 – 70 cm	(B) or AB; similar to A3, but without gravel and stones; structure: Pa large/Pa fine; diffuse and wavy smooth boundary with
70 – 100 cm	C - (R); like (R) in pit; with tongues of material like A horizon; P 1-2; R1

Soil type: intergrades between soil type 1 and 3; similar to pit 3, but with Me structure in Ap.
Soil classification: as pit 3
Sampling depths: 0-15, 20-40 and 50-70cm

PIT 5

Soil surface state: similar to pit 2;

0 – 25 cm	Ap; structure Me; very porous; distinct and smooth boundary to
25 – 55 cm	A2; melanic; structure Ps
55 – 60 cm	A3 stone line
60 – 100 cm	C&A: C = saprolite, + A like materials)

Soil type: Similar to pit 4 and 3. Most important difference: Stone line locally absent, if so, AC becomes B or A3, variegated brown- black
Soil classification: as pit 3
Sampling depths: 0-20, 30-50 and 65-90cm

PIT 6

Location: 20 m E of pit 5
Soil surface state: Similar to pit 5; slope 5-6%; some quarts gravels; intense activity of termites
Soil profile:

0 – 17 cm	Ap; black; structure Ma + Ps fine; P2; R3; distinct and smooth boundary to
17 – 55 cm	A2; black; structure Ps; P3; R3; gradual and wavy boundary to
55 – 85 cm	B (CA?); mixture of black and brown earth with some Q gravels; structure Ps; P2; R2; gradual transition to
85 – 120 cm	B2 (or B3?); yellowish red (5YR5/8) clay loam with abundant black nodules and concretions, discrete stone line with some quarts stone between 110 and 110 cm; structure Ma/Ps; P1, R1

Soil classification:
- *SA system*: Melanic A/ Yellow-Brown Apedal B or unspecified[15]?: (not reported in the handbook of the soils of the South African sugar industry)
- *WRB system:* Cambic Phaozem[16]
Effective rooting depth: > 120cm
Sampling depths: 0-15, 25 - 45 and 60 - 75cm

PIT 7
Location: 20 m W from a natural waterway that is flooded during rainy events
Soil surface state: almost flat; some gravels
Soil profile:

0 – 15 cm	Ap; dry; structure Ma/ Ps; R3; diffuse and smooth boundary with;
15 – 65 cm	A2; dry ->humid; black; structure Pa large/Ps fine; clayey loam to loamy clay; R2 to 4; some rounded quarts gravel; diffuse and smooth boundary with
65 - 95 cm	B, humid; strong brown (7.5YR 5/8) to yellowish red (5YR 5/8) with greyish parts; clayey loam with fine, black, pisolites and some rounded quarts stones; R2; diffuse and smooth boundary with
95 – 120 cm	Gox; wet; dark grey (10YR4/1) with red to yellowish (2.5 to 5YR4/6) mottles; clay loam with black pisolithes

Soil classification:
- *SA system*: Melanic A/ "unspecified" or yellowish-brown apedal B/oxidized G horizon: *soil form non reported in the handbook*
- *WRB system:* Cambic Gleyic Phaozem
Effective rooting depth: 100cm
Sampling depths: 0-15, 25 - 40 and 70 - 90cm

PIT 8
Soil surface state: flat; slope 5%
Soil profile:

0 -52 cm	A; dry; melanic; structure Ps; R3; clear smooth boundary with
52 – 63 cm	BA, dry, varigated; R2-3
63 – 90 cm	B; dry; red (2.5YR4/6), silty clay with 5-8 % of rounded quarts gravels and stones; structure PS, fine; R2-1
90 – 110 cm	Similar to 63-90 cm, but slightly humid.

Soil classification:
- *SA system*: Melanic A/ "unspecified"or or yellowish-brown apedal B/oxidized G horzon: *soil form non reported in the handbook*
- *WRB system:* Cambic Phaozem
Effective rooting depth: >100cm

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15 Named "unconsolidated material without signs of wetness" in the SA handbook for soils
16 At the moment not foreseen in the WRB system

Sampling depths: 0-15, 25 - 45 and 65 – 90 cm

PIT 9

Location: foot slope, 10 m E of a natural waterway
Soil surface state: flat; slope 4-5 %
Water table: at 170 cm depth
Soil profile:

0 – 12 cm	Ap; dry; black; structure Ma/Ps; distinct, slightly wavy boundary with
12 – 50 cm	A2; dry; black; structure Ps; P3-4; diffuse smooth boundary with
50 – 85 cm	B; slightly humid; very dark greyish brown (10YR3/2) with dark yellowish brown to yellowish brown (10YR4/6-5/8) patches; silty clay with some fine, black, pisolithes; diffuse smooth boundary with
85 – 110 cm	CGox; humid; mottling of red (2.5YR4/8), yellow (2.5Y7/6) and dark greyish brown (2.5Y4/2); P3; R1

Continued by auger:

110 - 160 cm	Similar to CGox
160 – 200 cm	CG; very humid

Soil classification:
- *SA system*: Melanic A/"unspecified"or or yellowish-brown apedal Boxidized G horizon/G horizon at great depth: *soil form non reported in the handbook*
- *WRB system:* Cambic Gleyic Phaozem

Effective rooting depth: >100cm
Sampling depths: 0-12, 45-55 and 55 – 85 cm

APPENDIX 3: Views of the soils and the environment of the site

End afternoon view on the SE part of the site and the bordering hills

View on the NE part of the site, the bordering wetlands and hills

The environment of the Amatikulu site (Cont.)

End afternoon view on the NE sector of the site, neighbouring wetland (with new bridge), and grazing cows

View on the natural grazing land with, in right upper part, old cane ridges; near soil pit 3

The environment of the Amatikulu site (Cont. 2)

Morning view on the SE part of the site and the bordering hills; view close from soil pit 4

Dark brown active termite mouth on foot slope part of the site; near soil pit 9

The environment of the Amatikulu site (Cont. 3)

Some flowering veld species

Views on the opened soil pits: Pit 1

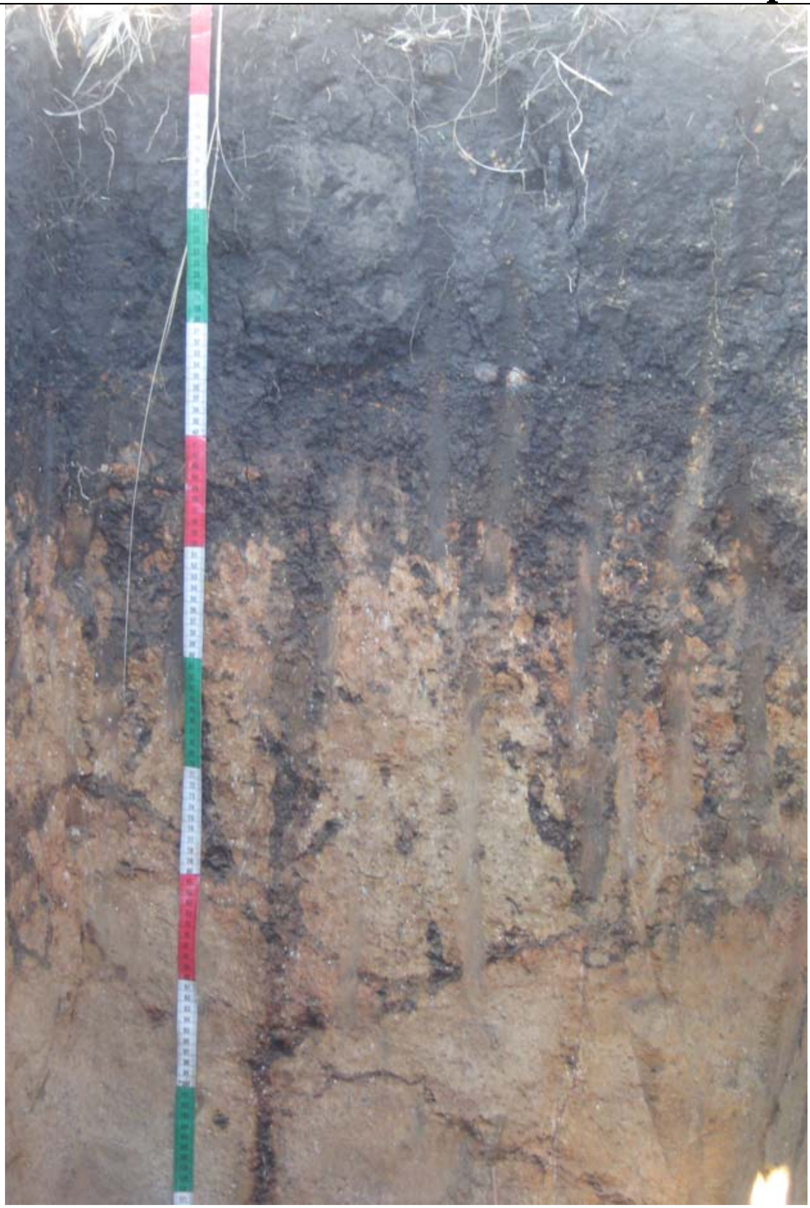
(Each coloured stretch = 10cm)

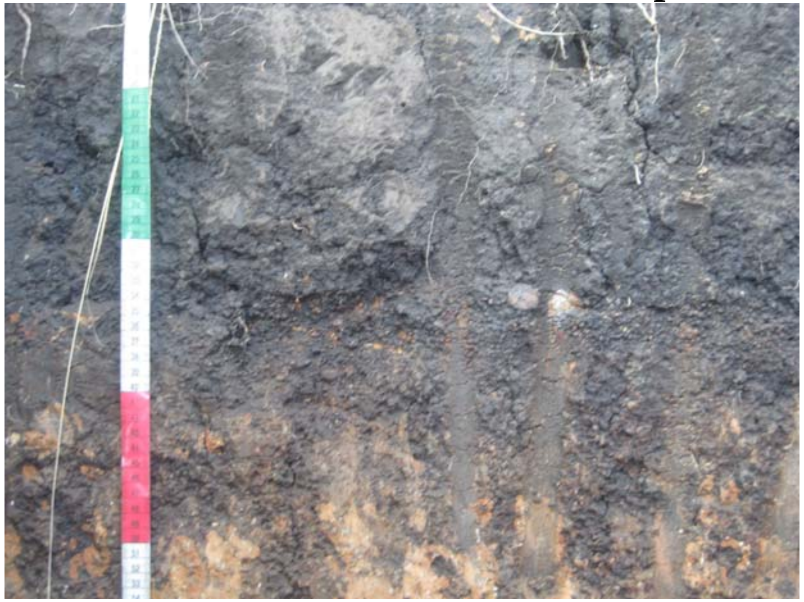
***Overall view** (except the very surface)*

Close-up of the tongues in the saprolite

Views of soil pit 2

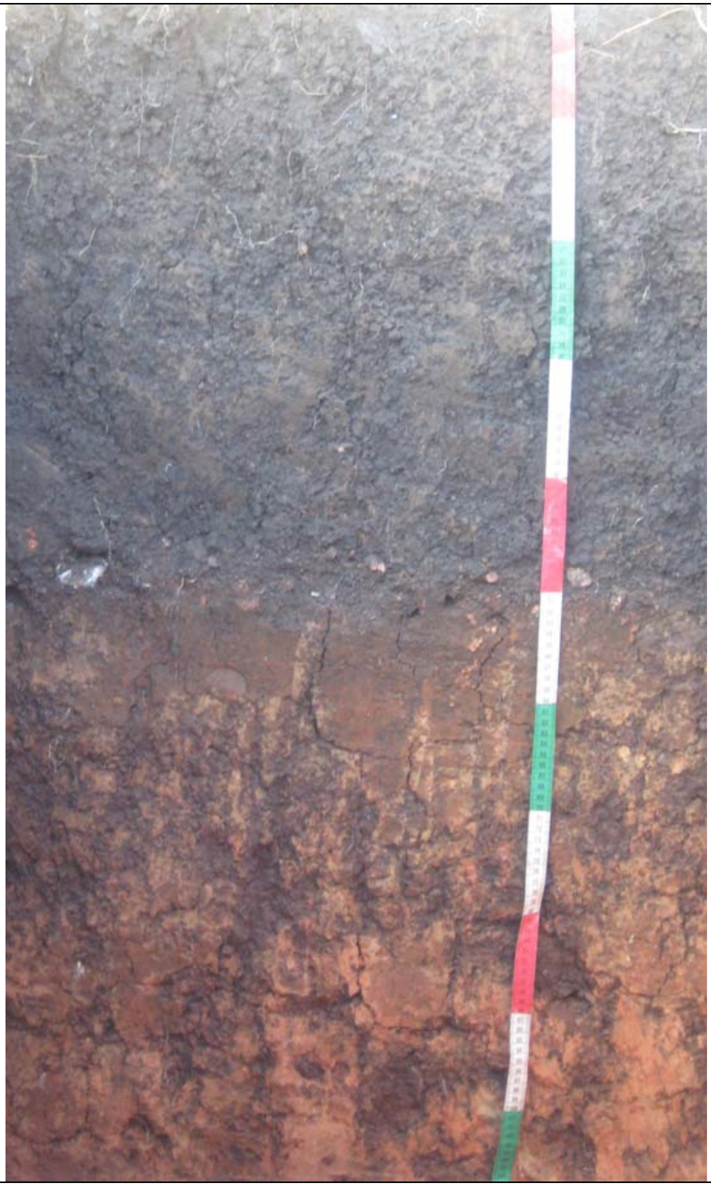
Overall view **Close-ups of A/C transition with some stones and of saprolite C**





Views of soil pit 3

Overview



Close-up of subsoil

View of soil pit 4

Note the distinct stone-line at the transition between the A & B horizons

Views of soil pit 5

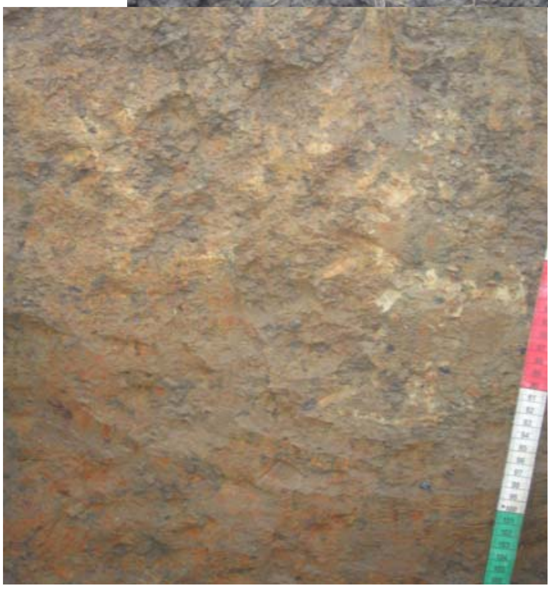
Overal viewwith distint stone-line

Surface state

Views of soil pit 9

Overview

Close-up of termite nest and of mottled horizon



APPENDIX 4: RESULTS SOIL ANALYSIS AS PRESENTED BY SASRI

Pit nbr	Depth cm	Hor type	Clay %	Silt %	*Sand %*	C tot %	*SOM %*	SOM % (NIR)	N Tot ppm	*N Cat.*	NH3 % index
1	0-20	Ap	42	8	*50*	2.09	*3.60*	8.7	600	*4*	0.1
	25-40	A2	42	4	*54*	2.27	*3.90*	8.7	900	*4*	0.1
	70-100	(R)	4	8	*88*	0.20	*0.34*	1.5	100	*1*	2.1
2	0-20	A1	36	8	*56*	2.00	*3.44*	8.6	700	*4*	0.1
	25-35	A2	44	6	*50*	1.86	*3.20*	8.1	700	*4*	0.1
	80-100	(R)	2	8	*90*	0.17	*0.30*	1.2	100	*1*	2.1
3	0-15	A1	42	6	*52*	2.66	*4.57*	9.6	1100	*4*	0.1
	24-40	A2	42	4	*54*	2.51	*4.31*	8.9	900	*4*	0.1
	60-90	A/C	57	6	*37*	1.14	*1.96*	7.1	500	*4*	0.2
4	0-15	Ap	40	6	*54*	1.99	*3.43*	7.9	700	*4*	0.1
	20-40	A2	36	6	*58*	2.22	*3.82*	9.2	700	*4*	0.1
	50-70	(B)	48	8	*44*	0.96	*1.65*	5.6	400	*4*	0.2
5	0-20	Ap	40	8	*52*	2.52	*4.33*	7.7	1100	*4*	0.1
	30-50	A2	42	6	*52*	1.95	*3.35*	6.2	500	*4*	0.1
	65-90	C/A	59	6	*35*	0.96	*1.65*	5.3	500	*4*	0.2
6	0-15	Ap	36	8	*56*	2.11	*3.62*	6.6	1000	*4*	0.1
	25-45	A2	34	11	*56*	2.13	*3.66*	6.9	900	*4*	0.1
	60-75	B	55	6	*39*	0.89	*1.54*	3.6	400	*3*	0.5
7	0-15	Ap	40	4	*56*	2.86	*4.91*	8.1	1500	*4*	0.1
	25-40	A2	40	2	*58*	1.92	*3.30*	6.6	700	*4*	0.1
	70-90	B	55	6	*39*	0.77	*1.33*	4.6	500	*4*	0.4
8	0-15	A1	40	8	*52*	2.94	*5.06*	8.2	1400	*4*	0.1
	25-45	A2	40	11	*50*	2.35	*4.04*	7.8	900	*4*	0.1
	65-90	B	63	6	*31*	1.08	*1.86*	7.1	400	*4*	0.3
9	0-15	Ap	38	4	*58*	2.58	*4.44*	7.7	1000	*4*	0.1
	20-45	A2	38	8	*54*	1.93	*3.31*	6.0	700	*4*	0.2
	55-85	B	44	6	*50*	1.05	*1.81*	2.1	500	*2*	2.3

Calculated values are in italique

APPENDIX 4: RESULTS SOIL ANALYSIS AS PRESENTED BY SASRI, (continued)

Pit nbr	Depth cm	pH water	pH *buffer*	*K^+* ppm	*Ca^{2+}* ppm	Mg^{2+} ppm	*Na^+* ppm	P ppm	PDI index	Si ppm	*Zn* ppm
1	0-20	5.5	6.7	134.7	1489.7	650	nd	8.7	0.4	67	1.5
	25-40	6..0	6.9	53.4	3072	872	nd	5.2	0.2	85	0.4
	70-100	7.4	7.7	25.4	4963	2080	214.8	>110	0.8	156	0.1
2	0-20	5.7	6.8	187.4	2412	626	nd	13.4	0.4	67	1.3
	25-35	6.1	6.8	54.9	2844	770	nd	12.4	0.3	89	0.5
	80-100	7.3	7.7	25.5	3008	1206	102.4	103.6	0.8	108	0.2
3	0-15	5.9	6.7	307.2	2651	815	nd	6.1	0.3	87	1.5
	24-40	6.5	6.9	51.3	3022	962	nd	5.4	0.2	102	0.4
	60-90	6.7	7.2	37.7	2409	1176	nd	11.5	0.1	210	0.1
4	0-15	5.6	6.5	133	1182.4	654	nd	6.4	0.3	58	2
	20-40	6.2	6.7	42.7	2543	718	nd	2.8	0.3	61	0.4
	50-70	6.7	7.2	40.8	1572.9	1207	nd	0.7	0.2	170	0.2
5	0-20	5.7	6.6	77.5	2684	779	nd	15.3	0.4	75	>4.0
	30-50	6.3	6.9	37	2660	783	nd	3.3	0.2	94	0.2
	65-90	6.8	7.3	40.8	2481	1081	nd	5	0.1	250	0.2
6	0-15	5.6	6.6	121.5	1405	705	nd	5.4	0.3	72	3.6
	25-45	6.2	6.9	42.6	2685	759	nd	2.6	0.2	89	0.2
	60-75	6.9	7.4	36.2	1108.2	874	nd	2.8	0.1	240	0.1
7	0-15	5.5	6.6	85.2	1410.6	627	nd	4.7	0.3	73	0.7
	25-40	6.2	6.9	39.3	3299	669	nd	2.4	0.2	83	0.2
	70-90	6.8	7.5	34.7	1206	631	nd	0	0.1	220	0.2
8	0-15	5.9	6.7	207.5	2655	1035	nd	11	0.3	112	2
	25-45	6.2	7	39.3	2662	879	nd	1.7	0.1	94	0.2
	65-90	6.8	7.3	27.9	1095.5	789	nd	11.7	0.1	300	0.1
9	0-15	5.6	6.6	53.2	1108.8	760	nd	6.5	0.3	86	0.8
	20-45	6.3	7.1	34.4	1467.3	723	nd	3.5	0.1	117	0.2
	55-85	7.8	7.9	30.8	1401.6	800	176.4	5.1	0.1	440	0.2

Calculated values are in italique

APPENDIX 5: RESULTS SOIL ANALYSIS, OTHERWISE PRESENTED

Pit nbr	Depth cm	Hor type	Clay %	Silt %	*Clay/ silt*	C tot %	*SOM %*	SOM % (NIR)	*SOM NIR/WB.*	*C/Clay ratio*	N tot ‰	*C/N*
1	0-20	Ap	42	8	*5.3*	2.09	*3.60*	8.7	*2.4*	5.0	0.6	*35*
	25-40	A2	42	4	*10.5*	2.27	*3.90*	8.7	*2.2*	5.4	0.9	*25*
	70-100	(R)	4	8	*0.5*	0.20	*0.34*	1.5	*4.4*	5.0	0.1	*20*
2	0-20	A1	36	8	*4.5*	2.00	*3.44*	8.6	*2.5*	5.6	0.7	*29*
	25-35	A2	44	6	*7.3*	1.86	*3.20*	8.1	*2.5*	4.2	0.7	*27*
	80-100	(R)	2	8	*0.3*	0.17	*0.30*	1.2	*4.0*	8.7	0.1	*17*
3	0-15	A1	42	6	*7.0*	2.66	*4.57*	9.6	*2.1*	6.3	1.1	*24*
	24-40	A2	42	4	*10.5*	2.51	*4.31*	8.9	*2.1*	6.0	0.9	*28*
	60-90	A/C	57	6	*9.5*	1.14	*1.96*	7.1	*3.6*	2.0	0.5	*23*
4	0-15	Ap	40	6	*6.7*	1.99	*3.43*	7.9	*2.3*	5.0	0.7	*28*
	20-40	A2	36	6	*6.0*	2.22	*3.82*	9.2	*2.4*	6.2	0.7	*32*
	50-70	(B)	48	8	*6.0*	0.96	*1.65*	5.6	*3.4*	2.0	0.4	*24*
5	0-20	Ap	40	8	*5.0*	2.52	*4.33*	7.7	*1.8*	6.3	1.1	*23*
	30-50	A2	42	6	*7.0*	1.95	*3.35*	6.2	*1.8*	4.6	0.5	*39*
	65-90	C/A	59	6	*9.8*	0.96	*1.65*	5.3	*3.2*	1.6	0.5	*19*
6	0-15	Ap	36	8	*4.5*	2.11	*3.62*	6.6	*1.8*	5.9	1.0	*21*
	25-45	A2	34	11	*3.1*	2.13	*3.66*	6.9	*1.9*	6.3	0.9	*24*
	60-75	B	55	6	*9.2*	0.89	*1.54*	3.6	*2.3*	1.6	0.4	*22*
7	0-15	Ap	40	4	*10.0*	2.86	*4.91*	8.1	*1.6*	7.1	1.5	*19*
	25-40	A2	40	2	*20.0*	1.92	*3.30*	6.6	*2.0*	4.8	0.7	*27*
	70-90	B	55	6	*9.2*	0.77	*1.33*	4.6	*3.5*	1.4	0.5	*15*
8	0-15	A1	40	8	*5.0*	2.94	*5.06*	8.2	*1.6*	7.4	1.4	*21*
	25-45	A2	40	11	*3.6*	2.35	*4.04*	7.8	*1.9*	5.9	0.9	*26*
	65-90	B	63	6	*10.5*	1.08	*1.86*	7.1	*3.8*	1.7	0.4	*27*
9	0-15	Ap	38	4	*9.5*	2.58	*4.44*	7.7	*1.7*	6.8	1.0	*26*
	20-45	A2	38	8	*4.8*	1.93	*3.31*	6.0	*1.8*	5.1	0.7	*28*
	55-85	B	44	6	*7.3*	1.05	*1.81*	2.1	*1.2*	2.4	0.5	*21*

Calculated values are in italique

APPENDIX 5: RESULTS SOIL ANALYSIS, OTHERWISE PRESENTED
(Continued)

Pit nbr	Depth cm	pH water	Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	*Σbases*	P avail. ppm	PDI	Zn avail. ppm	Si avail. ppm	*Si/Clay ratio*	*Si/C ratio*
			cmol^{+}.kg-1										
1	0-20	5.5	7.45	5.42	0.34	nd	*13.2*	8.7	0.4	1.5	67	*1.6*	*32*
	25-40	6.0	15.36	7.27	0.14	nd	*22.8*	5.2	0.2	0.4	85	*2.0*	*37*
	70-100	7.4	24.82	17.33	0.06	0.93	*43.1*	>110	0.8	0.1	156	*39*	*788*
2	0-20	5.7	12.06	5.22	0.48	nd	*17.8*	13.4	0.4	1.3	67	*1.9*	*34*
	25-35	6.1	14.22	6.42	0.14	nd	*20.8*	12.4	0.3	0.5	89	*2.0*	*48*
	80-100	7.3	15.04	10.05	0.07	0.45	*25.6*	104	0.8	0.2	108	*54*	*621*
3	0-15	5.9	13.26	6.79	0.79	nd	*20.8*	6.1	0.3	1.5	87	*2.1*	*33*
	24-40	6.5	15.11	8.02	0.13	nd	*23.3*	5.4	0.2	0.4	102	*2.4*	*41*
	60-90	6.7	12.05	9.80	0.10	nd	*21.9*	11.5	0.1	0.1	210	*3.7*	*184*
4	0-15	5.6	5.91	5.45	0.34	nd	*11.7*	6.4	0.3	2.0	58	*1.5*	*29*
	20-40	6.2	12.72	5.98	0.11	nd	*18.8*	2.8	0.3	0.4	61	*1.7*	*27*
	50-70	6.7	7.86	10.06	0.10	nd	*18.0*	0.7	0.2	0.2	170	*3.5*	*177*
5	0-20	5.7	13.42	6.49	0.20	nd	*20.1*	15.3	0.4	>4.0	75	*1.9*	*30*
	30-50	6.3	13.30	6.53	0.09	nd	*19.9*	3.3	0.2	0.2	94	*2.2*	*48*
	65-90	6.8	12.41	9.01	0.10	nd	*21.5*	5	0.1	0.2	250	*4.2*	*260*
6	0-15	5.6	7.03	5.88	0.31	nd	*13.2*	5.4	0.3	3.6	72	*2.0*	*34*
	25-45	6.2	13.43	6.33	0.11	nd	*19.9*	2.6	0.2	0.2	89	*2.6*	*42*
	60-75	6.9	5.54	7.28	0.09	nd	*12.9*	2.8	0.1	0.1	240	*4.4*	*268*
7	0-15	5.5	7.05	5.23	0.22	nd	*12.5*	4.7	0.3	0.7	73	*1.8*	*26*
	25-40	6.2	16.50	5.58	0.10	nd	*22.2*	2.4	0.2	0.2	83	*2.1*	*43*
	70-90	6.8	6.03	5.26	0.09	nd	*11.4*	0	0.1	0.2	220	*4.0*	*284*
8	0-15	5.9	13.28	8.63	0.53	nd	*22.4*	11	0.3	2.0	112	*2.8*	*38*
	25-45	6.2	13.31	7.33	0.10	nd	*20.7*	1.7	0.1	0.2	94	*2.4*	*40*
	65-90	6.8	5.48	6.58	0.07	nd	*12.1*	12	0.1	0.1	300	*4.8*	*278*
9	0-15	5.6	5.54	6.33	0.14	nd	*12.0*	6.5	0.3	0.8	86	*2.3*	*33*
	20-45	6.3	7.34	6.03	0.09	nd	*13.4*	3.5	0.1	0.2	117	*3.1*	*61*
	55-85	7.8	7.01	6.67	0.08	0.77	*14.5*	5.1	0.1	0.2	440	*10*	*419*

Calculated values are in italique

APPENDIX 6: SOIL ANALYTICAL METHODS at SASRI/FAS

Clay, silt & sand %: Clay % and silt % determined by a simplified hydrometer method; sand % by difference. Simplification by: no destruction of soil organic matter by H_20_2, steering with a mixer, and, silt % measurement after 4 minutes and clay after 2 hours.

C% & SOM (Soil organic matter) %: Extraction with 1N $K_2Cr_2O_7$ + H_2SO_4 conc. + H_3PO_4 + NaF; Titrate = 1n $FeSO_4.7H_2O$; Indicator: diphenylamine (Walkey-Black method). SOM = 1.742 C %.

OM% Estimated: Determined by NIR
Comment: Result should not be interpreted as a quantitative. Obtained value used for ranging the analysed topsoils in one of SASRI's 4 classes of capacity to mineralization (and thus N-mineral purchase to the crop) of the soil organic matter.

Total N: Determined after steam distillation, extraction of N with K_2SO_4; MgO for NH_4 amount and Devarda for the NO_3 amount

NH_3 %: An estimate of the amount of ammonia that would be lost by ammonia volatilization following the topdressing of urea, based on measuring the change in pH in an ammonium bicarbonate buffer solution.

N category: An index of the amount of N likely to be released by the soil.
Determined according to OM% estimated and Clay% estimated. The category gives an indication of the amount of N potentially mineralized by the top soil during the growing season of sugarcane, ranged in 4 categories. N recommendations are adjusted based on this index

Exchangeable bases (Ca, Mg, K, Na): Extraction with 1 N Ammonium Acetate, not tampered; measurement by Atomic Absorption Spectroscopy (AAS)

Zi (Zinc): Extraction with (780 g) Ammonium Carbonate + (37.2g) EDTA (in 10 l) of water; measurement by AAS.

Si: Extraction with 0.05 N sulphuric acid.

pH-water: For soil/water ratio of 4/10 after shaking for 20 min.
pH-buffer: Done for a soil/solution ratio of 4/10; buffer made of (81.73g) NH_4HCO_3 + (19.07g) NaOH (in 2 l); Comment: Result used for appraisal of NH_3%

P (available P): Extraction with 0.002N H_2SO_4; shaking for 20 min., centrifuge, P measured by colorimeter (modified Truog method)

PDI (Phosphorus desorption index)
On sub samples A & B: Extraction during one night A with water, and B with 200 ppm P and solution/soil ratio of 1/1; followed by adding Bray 2 solution and shaking 1 min.
Interpretation of the results: <0.2 = strong P fixation; 0.2-0.4 = medium; >0.4: weak P fixation. If PDI is low (= high P fixation capacity) more P fertilizer is recommended than for soils with high PDI value.

APPENDIX 7: SOIL THRESHOLD VALUES FOR SUGARCANE GROWING

(Source: Using soil and leaf analysis to make fertiliser recommendations, FERTILISER ADVISORY SERVICE, (FAS) March 2006)

Phosphorus (P) 31 ppm for plant cane
11 ppm for ratoons

Potassium (K) 112 ppm if clay content ≤ 30%
150 ppm (340 kg/ha) if clay content ≥ 30%
225 ppm (500 kg/ha) in northern irrigated areas (NIA) if clay >40%
325 ppm (750 kg/ha) in NIA, if clay >40% and Ca+Mg,>4000 ppm

Calcium (Ca) 200 ppm (450 kg/ha)

Magnesium (Mg) 25 ppm (60 kg/ha)
75 ppm if calcium is also deficient

Sulphur (S) 15 ppm

Zinc (Zn) 0.5 ppm if clay content ≤ 15%
1.0 ppm if clay content >15%
1.5 ppm in Midlands soils where > 3 tons/ha lime is recommended

Nitrogen (N) based on the N category, i.e. the potential of the soil to mineralise N from soil organic matter: 4 = very high, 3 = high, 2 = medium, and 1 = low

CROP CRITERIA		Soil N mineralisation category			
		LOW -1	MODERATE -2	HIGH - 3	VERY HIGH - 4
Plant crop	Rainfed Irrigated	120 140	100 120	80 80	60 60
RATOONS	**Coastal** Rainfed Irrigated	***Rooting depth*** <400 mm >400 mm 140 160 160 180	140 160	120 120	100# 100#
	Midlands Rainfed Irrigated	140 160 140 160	120 140	120 120	100 100
	Lowveld Irrigated	160 200	160	120* 140**	N/A

* 1st to 4th ratoon ** older than 4th ratoon # peat soils

Silicon (Si):

≤ 45 ppm if ≤ 15% clay
≤ 65 ppm if 15 - 30% clay
≤ 100 ppm if > 30% clay

Some complementary information on the management of P and K fertility of the soils

Phosphorus (P)

A. WHOLE CYCLE ADVICE FOR PLANT CANE

*1. All areas (*except KwaZulu-Natal Midlands): threshold 40 ppm

2. Midlands areas only (i.e. above 300 m altitude): according to threshold of 40 ppm and the phosphorus desorption index (PDI): strongly P-fixing (PDI<0.2), moderately (0.2 to 0.4), weakly P-fixing (PDI >0.4).

B. RATOON CANE

*1. All areas (*except KwaZulu-Natal Midlands)*:* threshold 13 ppm

2. Midlands areas only: according to threshold of 31 ppm and the phosphorus desorption index (PDI)

Potassium (K)

A. WHOLE CYCLE ADVICE FOR PLANT CANE

1. Soils with clay content ≤ 30% threshold (including fertiliser advice): 130 ppm

2. Soils with clay *content ≥ 30%*[17] threshold (including fertiliser advice): 165 ppm

3. Soils with >40% clay in the Northern irrigated areas (lowveld), and:

- *Medium* base status (Ca+Mg <4 000 ppm): threshold (including fertiliser advice): 245 ppm
- *High* base status (Ca+Mg >4 000 ppm): threshold (including fertiliser advice) 350 ppm

B. RATOON CANE

*1. All soils (*except Northern Irrigated Areas):

Potassium requirement is calculated on the basis of soil K level and clay content using the relationship: K-fertiliser need[18] (kg/ha) = $416.2 + (0.07285 \times C^2) - (33.42 \times \sqrt{K})$ Where C = clay %, and K = soil K (ppm)

The K threshold value goes from 210 ppm for a soil with >40% clay to 120 ppm for a soil with only 5 % clay

2. Northern Irrigated Areas: for soils with >40% clay, and high base status: threshold 325 ppm

[17] Except for soils with >40% clay in the Northern Irrigated Areas

[18] For potassium fertilisation with KCl